



Calorimeter Digitalization and Calibration and pre-CDR plots

Jin Huang (BNL)

Calorimeter Tower Handling



Pull request:

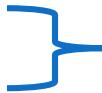
<https://github.com/sPHENIX-Collaboration/coresoftware/pull/41>

Example macro:

[https://github.com/sPHENIX-Collaboration/macros/blob/master/macros/g4simulations/G4_CEmc_Spacal.C :: void CEMC_Towers\(\)](https://github.com/sPHENIX-Collaboration/macros/blob/master/macros/g4simulations/G4_CEmc_Spacal.C :: void CEMC_Towers())

New organization of the DST nodes

- G4Hit* <- from production
- BBC (PHCompositeNode)/
 - BbcVertexMap (PHIODataNode)
- SVTX (PHCompositeNode)/
 - G4CELL_SVTX (PHIODataNode)
 - SvtxHitMap (PHIODataNode)
 - SvtxClusterMap (PHIODataNode)
 - SvtxTrackMap (PHIODataNode)
 - SvtxVertexMap (PHIODataNode)
- CEMC (PHCompositeNode)/
 - G4CELL_CEMC (PHIODataNode)
 - TOWER_SIM_CEMC (PHIODataNode)
 - TOWER_RAW_CEMC (PHIODataNode)
 - TOWER_CALIB_CEMC (PHIODataNode)
 - CLUSTER_CEMC (PHIODataNode)
- HCALIN (PHCompositeNode)/
 - G4CELL_HCALIN (PHIODataNode)
 - TOWER_SIM_HCALIN (PHIODataNode)
 - TOWER_RAW_HCALIN (PHIODataNode)
 - TOWER_CALIB_HCALIN (PHIODataNode)
 - CLUSTER_HCALIN (PHIODataNode)
- HCALOUT (PHCompositeNode)/
 - G4CELL_HCALOUT (PHIODataNode)
 - TOWER_SIM_HCALOUT (PHIODataNode)
 - TOWER_RAW_HCALOUT (PHIODataNode)
 - TOWER_CALIB_HCALOUT (PHIODataNode)
 - CLUSTER_HCALOUT (PHIODataNode)



Current implementation:

RawTowerv1

- unified tower ID (unsigned int)
- An energy value (double)
- List of contributing cells (map of ids->weight)

<https://www.phenix.bnl.gov/WWW/sPHENIX/doxygen/html/db/d3c/classRawTowerv1.html>

DST/G4Hit_* : Geant4 hit raw info from production

- **PHG4CylinderCellReco** : Group hits into subunit of detector, e.g. fiber/scint tile

DST/G4CELL_*: Summed G4hit in energy and light yield

- **RawTowerBuilder**: group cells into towers (physical calorimeter channel). Options to use sum of total energy deposition or sum of visible energy (a.k.a. light_yield())

DST/TOWER_SIM_*: list of contributors and summed energy

- **RawTowerDigitizer** : convert G4 light yield into digitalized ADC values. Two options supported right now through set_digi_algorithm()
 - *kNo_digitalization* : directly pass the energy of sim tower to digitalized tower
 - *kSimple_photon_digitalization*: digitalization with Poission photon statistics, ADC conversion and pedestal

DST/TOWER_RAW_*: list of contributors and ADC value

- **RawTowerCalibration** : Algorithm switch with RawTowerCalibration::set_calib_algorithm
 - *kNo_calibration*: directly pass the energy of raw tower to calibrated tower. Zero suppression is applied
 - *kSimple_linear_calibration* : simple calibration with pedestal subtraction and a global energy scale (sampling fraction) correction

DST/TOWER_CALIB_*: list of contributors and calibrated total energy in tower

- **RawClusterBuilder**: Graph clusterizer / **RawClusterBuilderv1** : PHENIX clusterizer

DST/CLUSTER_*: Clustered towers and summed calibrated energy

Pre-CDR preparation for EMCal

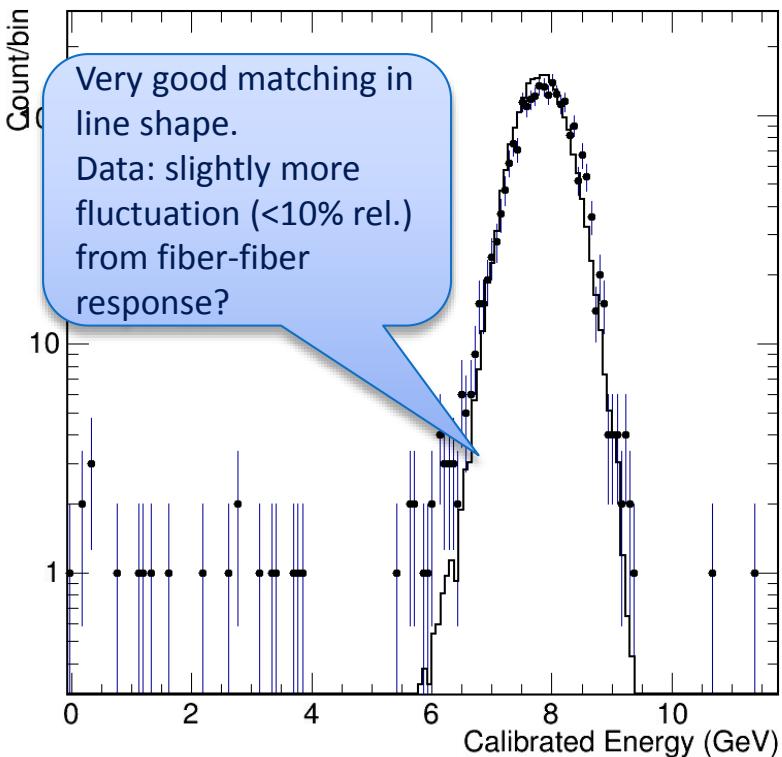


Pre-CDR plots

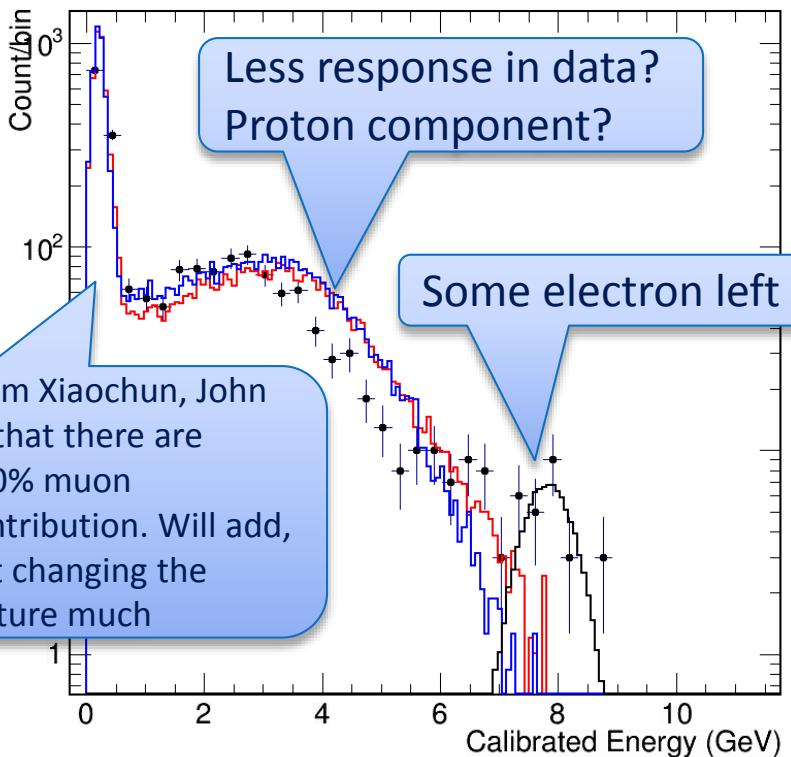
- ▶ Single particle (e/mu/pi/p/gamma/pi0)
 - Line shapes [Jin] <- Done
 - Event display [Jin] <- Done
 - Sampling fraction [Jin] <- Done
 - Linearity [Jin] <- Checking
 - Energy resolution [Jin] <- Done
 - Lateral extension [Jin] <- Done : Use old plots
 - Dynamic range [Jin] <- Done
- ▶ Au+Au HIJING embedded
 - Underlying event energy and fluctuation [Jin]
 <- Working on it
 - Rejection vs efficiency for electrons [Jin]
 <- verify analysis tools, need high stat. e, hadron sim (100k)
 - Photon resolution [Stefan and Megan]
 <- Promising PHENIX Clusterizer, need embedding
- ▶ EM energy trigger performance
 - Turn-on curve [Jin] <- need Pythia production

Test beam comparison: 8 GeV beams shower in Geant4 VS data

Electron Sim (line) VS data (point)



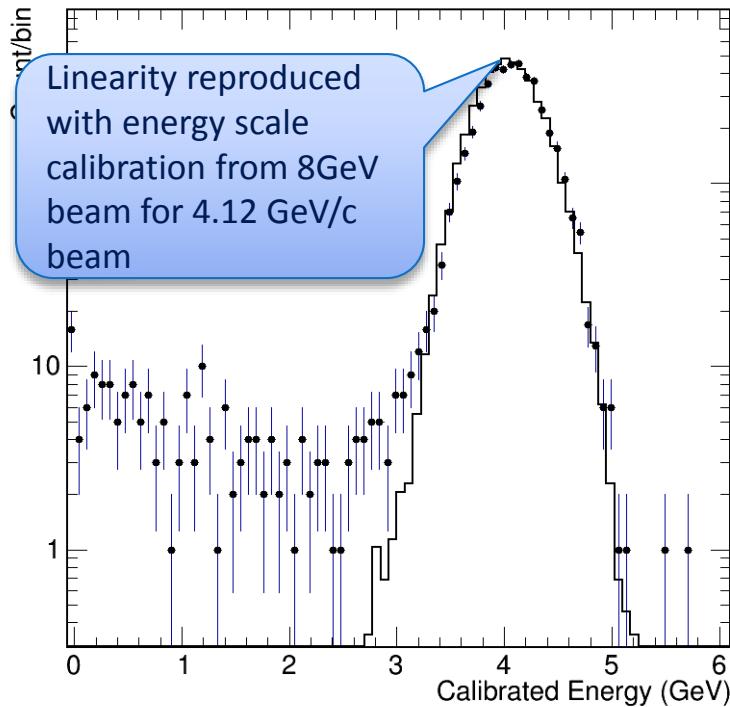
Pion- (red) K- (blue) e contain. (black) Sim VS data



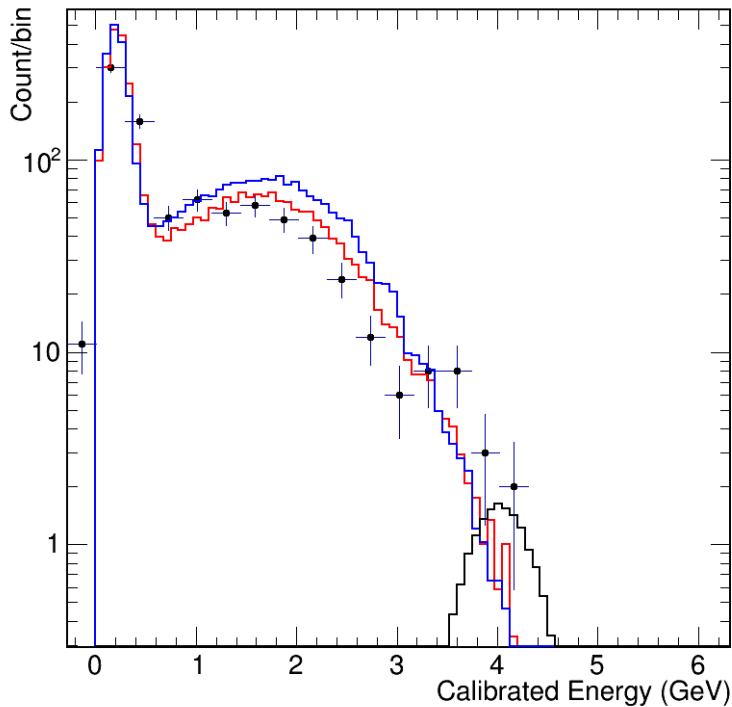
Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

Test beam comparison: 4.12 GeV/c beams shower in Geant4 VS data

Electron Sim (line) VS data (point)



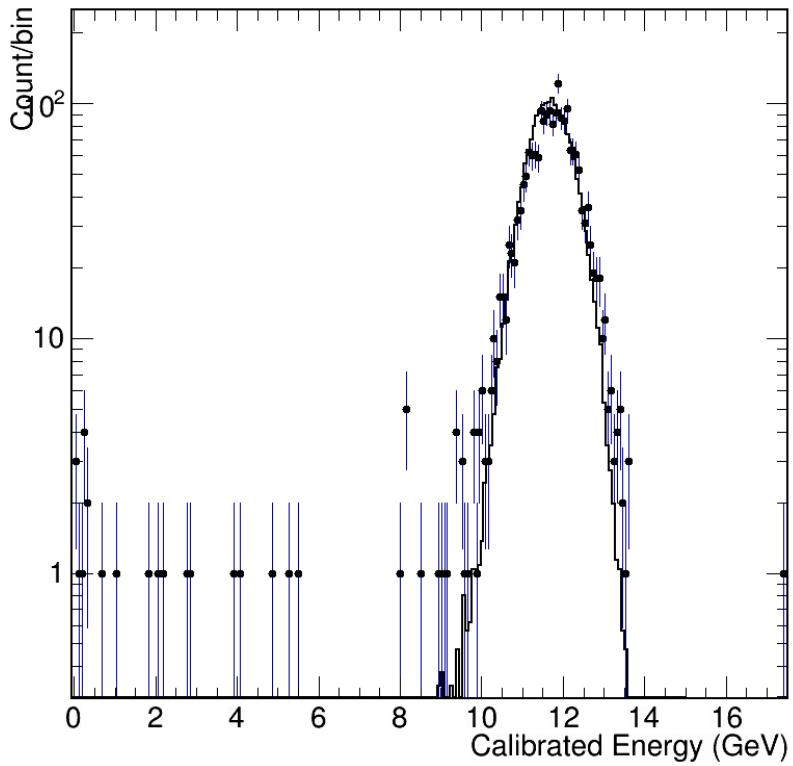
Pion- (red) K- (blue) e contain. (black) Sim VS data



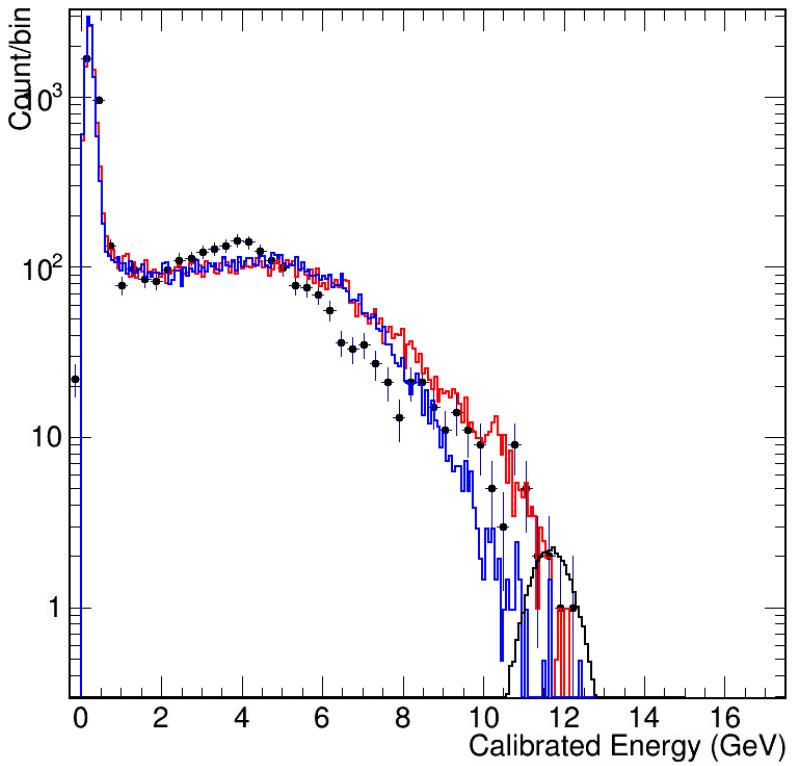
Full Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (2ADC), photon fluctuation (500e/GeV), NO fiber/fiber response

Test beam comparison: 12 GeV/c beams shower in Geant4 VS data

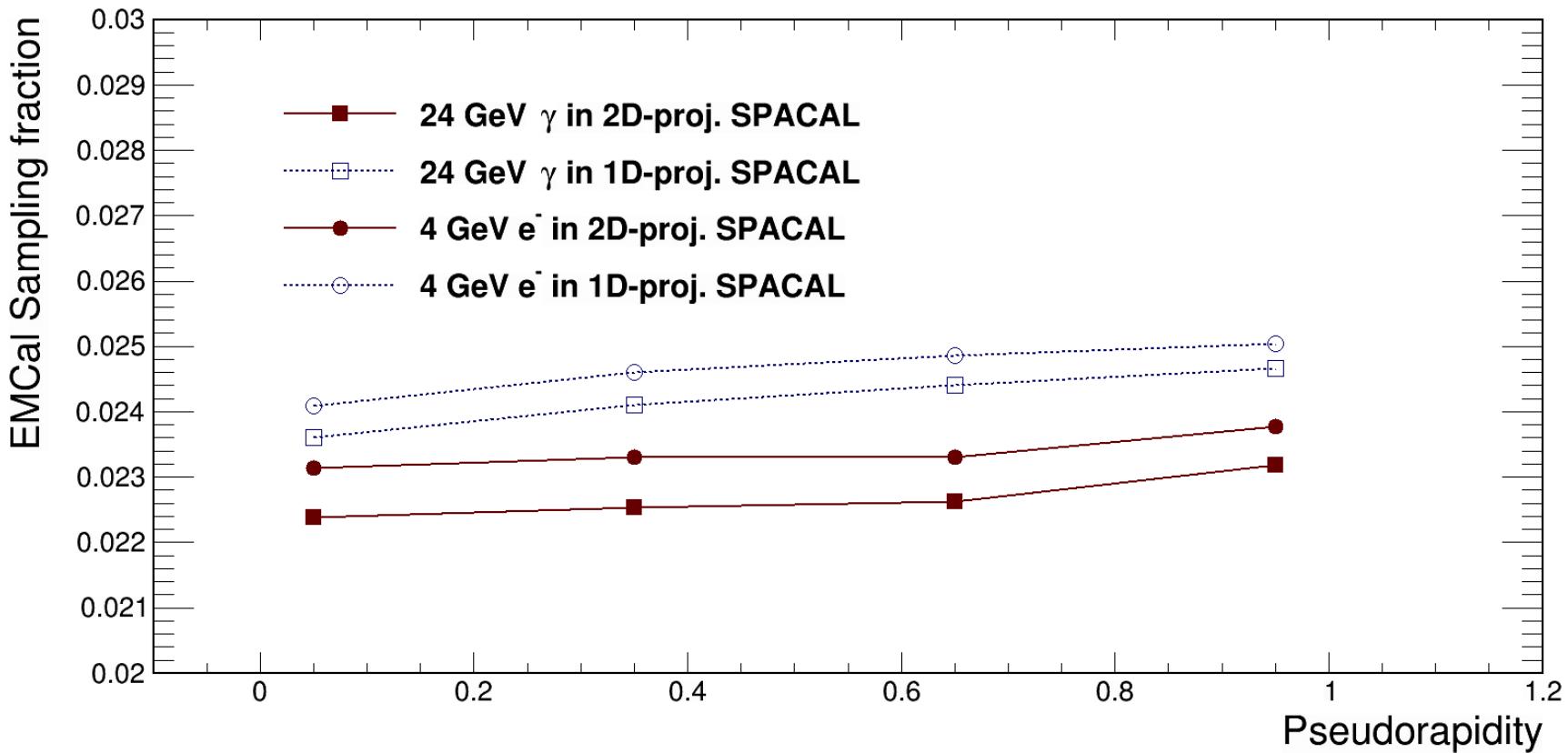
Electron Sim (line) VS data (point)



Pion- (red) K- (blue) e contain. (black) Sim VS data



Sampling Fraction



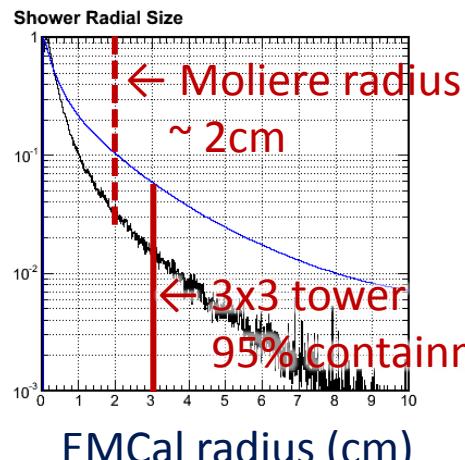
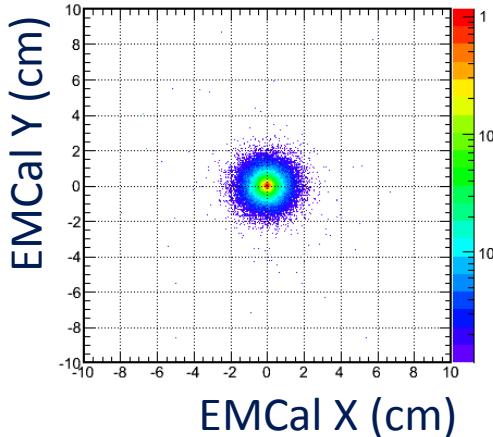
/direct/phenix+sim02/phnxreco/ePHENIX/jinh
uang/sPHENIX_work/single_particle/DrawEcal
_DrawSF.pdf

Spatial response

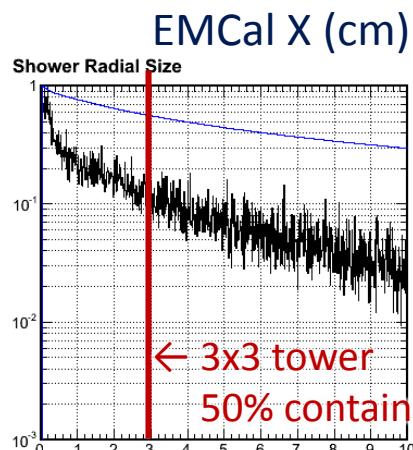
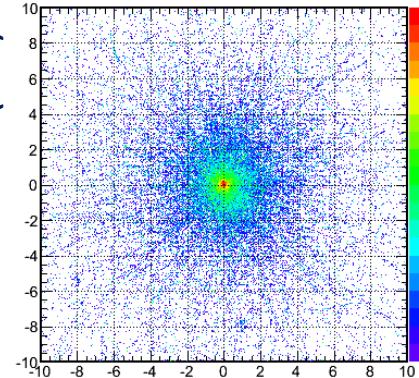
- Spacial containment of showers → size of cluster

- Energy deposition (A.U.)
- Percentage outside radius

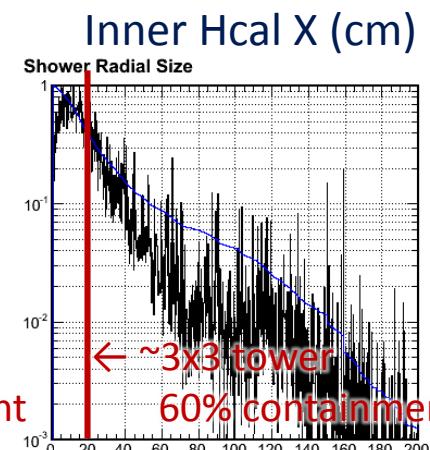
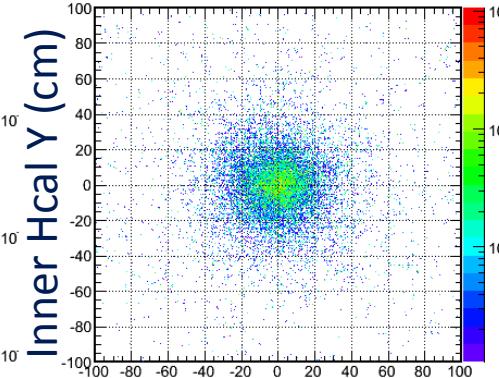
4 GeV Electrons



4 GeV Pions, that passed E/p electron-ID cut



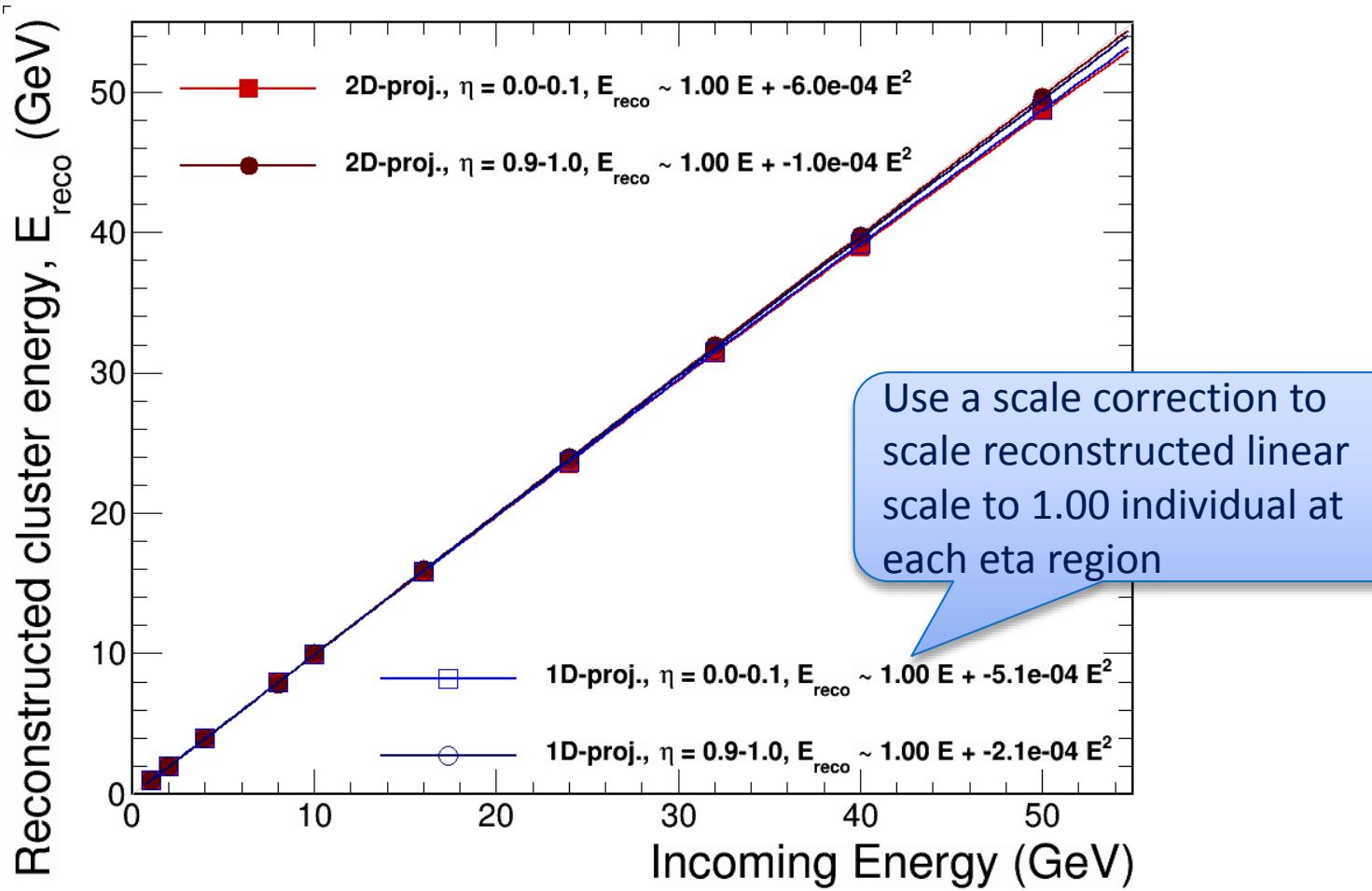
EMCal radius (cm)



Inner Hcal radius (cm)

Linearity – double checking

Simulated with single photons



Full detector Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe), Graph clusterizer

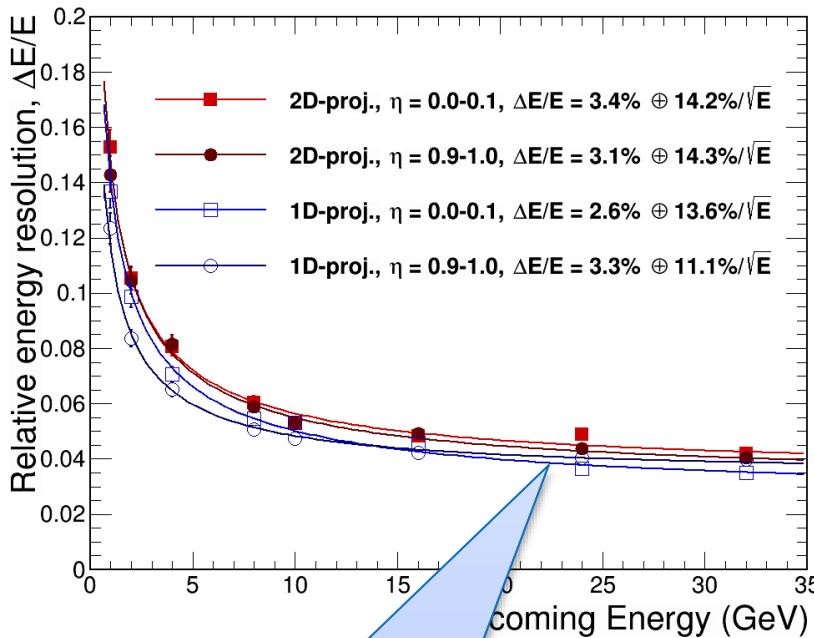
Energy resolution

Simulated with single photons

Full detector Geant4 sim QGSP_BERT_HP + light yield model (Geant4 default Birk)

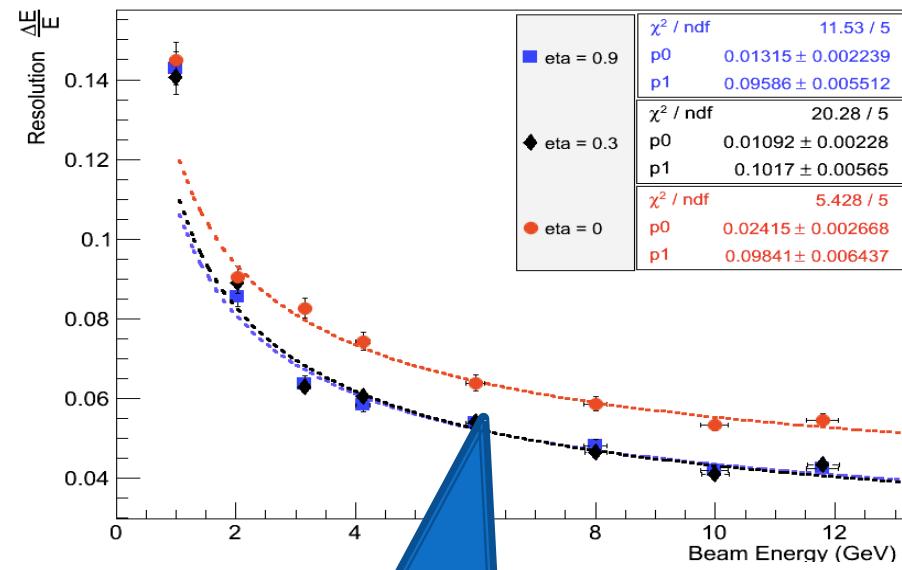
Pedestal noise (8pe), photon fluctuation (500pe/GeV), Zero sup (16pe), Graph clusterizer

sPHENIX full detector single photon simulation



1D SPACAL in forward rapidity has lowest $1/\sqrt{E}$ term due to higher sampling fraction from radially shallow showers

EIC RD1 study
FermiLab beam tests

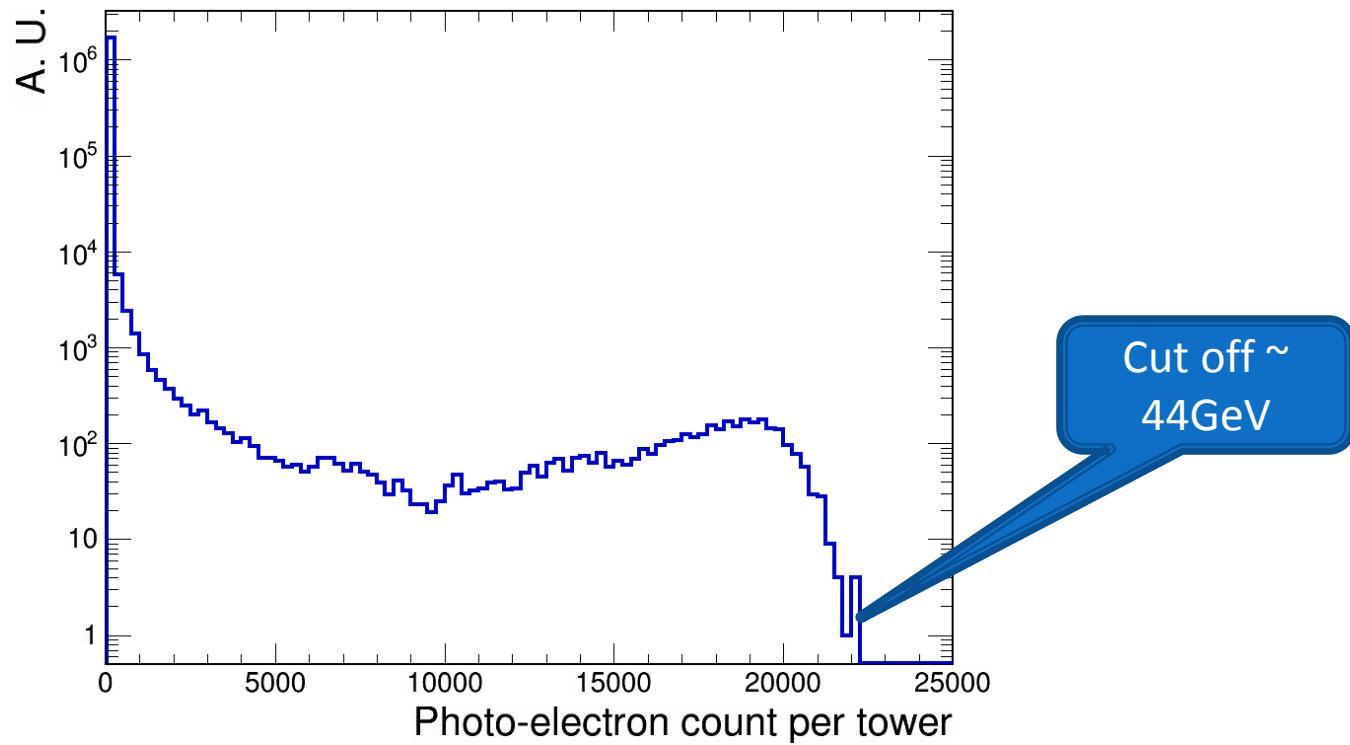


Courtesy: A.Kiselev (BNL)
DIS2014

Used [1] + [2]/sqrt(E) in fit instead of sqrt sum??

Dynamic range plot

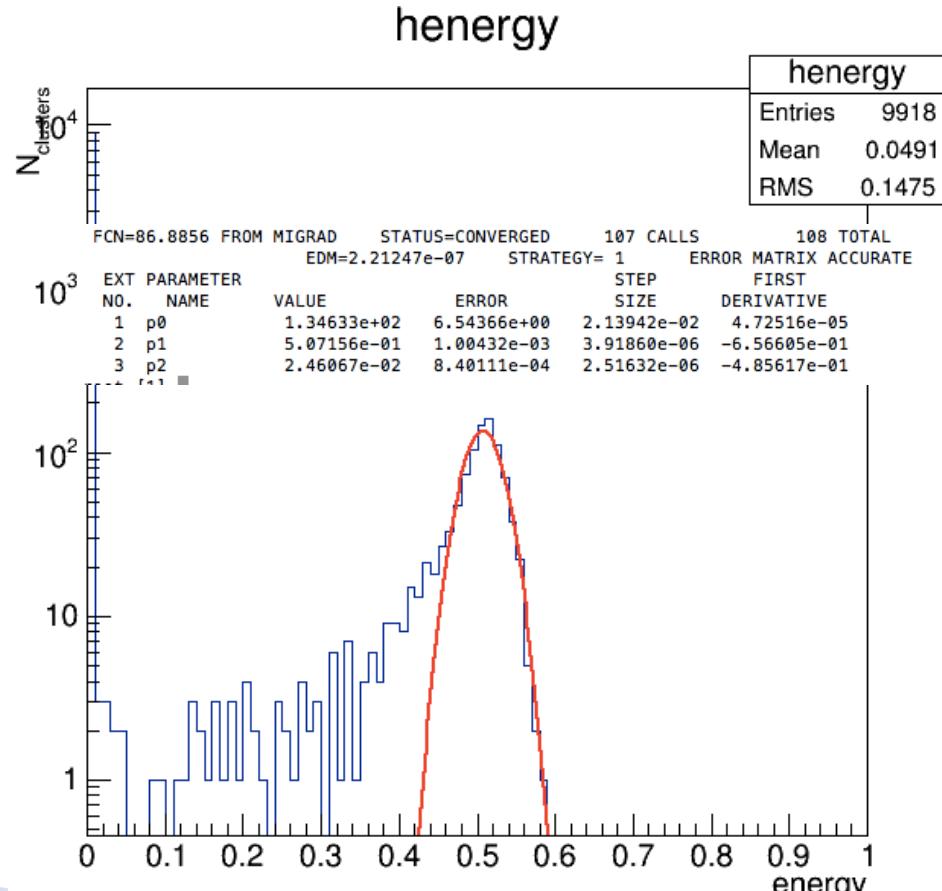
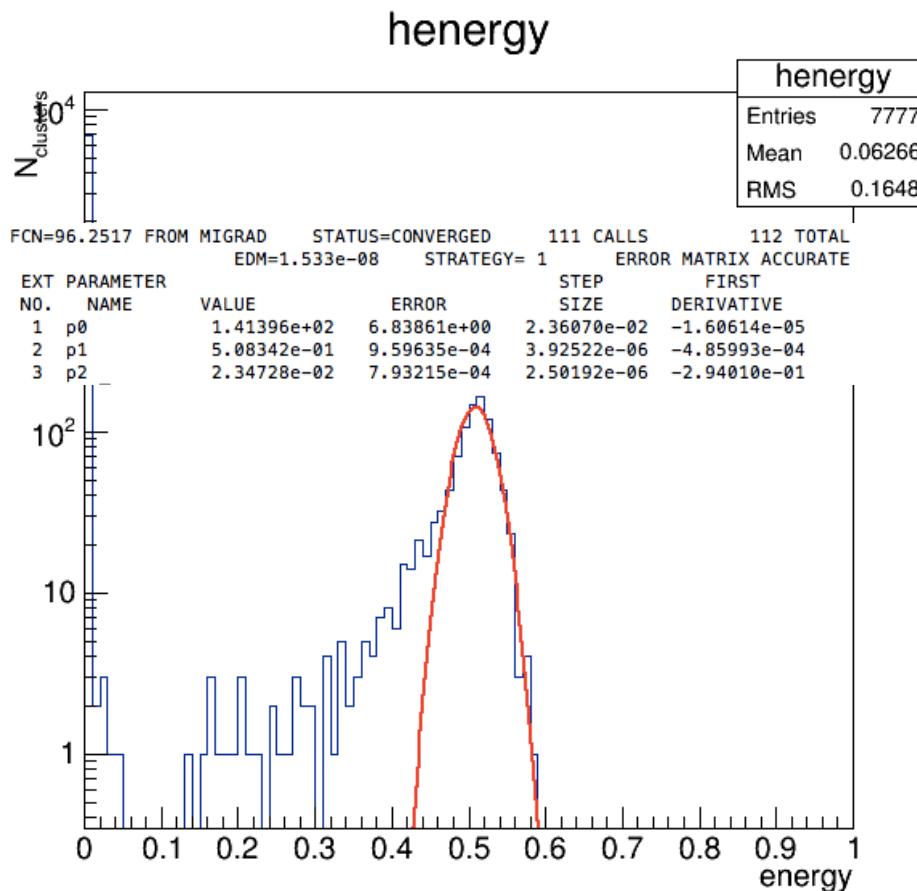
- 50 GeV photon shower in 2D-projective SPACAL, all eta ranges
- Plot photon observed per tower per event
- max $\sim 22k$ photon/tower (44GeV/tower), pedestal $\sigma \sim 8$ photon
- Range ~ 12 bit (max/pedestal 1 σ)



Photon performance [Megan and Stefan]

- PHENIX Clusterizer from Sasha B. survived PHENIX->sPHENIX migration.
 - Promising use of the PHENIX Clusterizer in HI embedded events
- Fit with Gaus
- $[0]*\exp(-0.5*((x-[1])/[2])^2)$

Plots from Megan Connors (GSU)



Further production request

- ▶ Electron and hadron simulation with higher statistics (100x now \sim 100k total):
 - Few percent stat. error on rejection ratio plot after pi-e separation cuts in p/p
 - Beat down statistics of the likelihood function
- ▶ Pythia events (10k – 100k), full magnetic field
 - 20% stat. error after 5000:1 trigger rejection
- ▶ Single Electron simulation (1000 event), sPHENIX magnetic field, but NO silicon detectors
 - Intrinsic performance for EMCal